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'I already know about it, I've been watching the Daily News and updates': Teenagers' questions about the scientific and social aspects of COVID-19

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ABSTRACT

Since the start of the COVID-19 pandemic, there has been a surfeit of information and misinformation in the media about it. The lockdown in England meant that schools were closed from March to June, meaning that students had limited access, in school, to ask questions and discuss the biology of the novel virus (SARS-CoV-2) or the impact of the pandemic on themselves, their families and friends. In this small-scale exploratory study, we decided to ask students (15–16-year-olds) on their return to school in June 2020 and in September 2020, what they wanted to know about COVID-19. Findings show that their questions were similar at both time points, indicating that students wanted to know the same things. This suggests that despite the high volume of information available in the media, some of the students' questions had not been answered or that sources of information were confused and at times contradictory. Interestingly, the questions they asked were based on reliable sources of news rather than fake news, and this finding seems to contradict the literature that indicates young people are prone to believing misinformation. The implications for teaching and learning about COVID-19, and other zoonotic diseases as socio-scientific issues are discussed.

KEYWORDS

COVID-19; pandemic; misinformation; socio-scientific issues; anxiety; science/ health literacy

Background

As the novel coronavirus, SARS-CoV-2 swept across the world in early 2020, causing the disease COVID-19, the World Health Organisation (WHO) declared on 11 March that it was a pandemic (WHO, 2020). Since then, there has been a surfeit of information about the disease from global, as well as national, organisations that have been in constant flux (O'Connor and Murphy 2020; Samuelsson, Wagner, and Ødegaard 2020). In the UK daily briefings from government ministers, the Scientific Advisory Group for Emergencies (SAGE) and Public Health England (PHE) relayed data on infection rates, mortality rates, the epidemiology of the virus, advice about infection control, as well as mandatory measures to reduce the spread of the virus. These included school closures, even though the effect of such measures on reducing the level of infection remained unclear (Viner et al. 2020). Initially, some information was contradictory (e.g. advice about face coverings), and since then, regulations have frequently changed, and are often different within and between countries, and this has caused public confusion. This information overload, or 'infodemic', has also been characterised by high levels of misinformation about the virus, and fake news has swirled in the media and on social media platforms (O'Connor and Murphy 2020; Orso et al. 2020; Roozenbeek et al. 2020a; Rose 2020; van der Linden, Roozenbeek, and Compton

2020). UNESCO (2020) coined the term ‘disinfodemic’ stating that COVID-19 has engendered a parallel pandemic of disinformation that directly impacts lives and livelihoods around the world.

Consequently, factually incorrect information, hearsay and conspiracy theories are widely available to the public and when these go unchallenged they can proliferate and go ‘viral’ with devastating consequences for some (Rose 2020). van der Linden, Roozenbeek, and Compton (2020) and Roozenbeek et al. (2020a) note that COVID-19 misinformation can detrimentally influence the adoption of health behaviours in the population. Those who are more impressionable about misinformation are more likely to be vaccine hesitant, less likely to recommend vaccination to others, and be less willing to comply with public health guidance measures. However, resistance to misinformation has been noted, particularly in those who are media literate (Amazeen & Bucy, 2019), have liberal political and world views and are scientifically, health or numerically literate (Roozenbeek et al. 2020a). Conversely, mistrust in scientists, mainstream media and politicians, as well as age, can increase the susceptibility to misinformation (Roozenbeek et al. 2020b). Roozenbeek et al. (2020a) found that young people are more susceptible to untruths about COVID-19 than their elders. This may inadvertently cause harm to themselves or others; for example, not adhering to social distancing rules may increase infection rates, or not getting vaccinated will reduce the efficacy of a vaccine programme (Dryhurst et al. 2020).

Pandemics and other extreme events have also been shown to have a negative impact on the general wellbeing, mental and physical health, and educational outcomes of young children (de Walque 2011). Studies of previous epidemics have shown that after schools reopen there is a marked change in children’s behaviour with a dramatic decrease in social interaction, feeling uncomfortable at having to wear a mask and difficulties in adjusting to more formal classroom arrangements (Rao 2006). Whilst the findings of this research refer to the impact on young children, it can be assumed that similar non-medical effects are felt by older students. For example, Brooks et al.’s (2020) review of the psychological harms of quarantine noted that social isolation brings a range of problems including post-traumatic stress symptoms, confusion, and anger and that they can have long-lasting effects. Whilst Rose (2020) notes that the consequences of COVID-19 have aggravated mental health issues and increased the cases of depression, anxiety and suicide. Therefore, the isolation caused by the lengthy lockdown in the UK during the early summer months coupled with uncertainty about what to believe about COVID-19 may have led to anxiety for school-aged students and have had a detrimental impact on their well-being. However, the impact of long-term school closure on educational outcomes, and the wellbeing of young people has not yet been fully explored (Viner et al. 2020).

Well before the COVID-19 pandemic, social media had become a major source of information for many people, with the digital revolution transforming the way information is relayed to the public. Alongside a growing discontent with ‘experts’ and distrust of the establishment and politicians, social media platforms have been able to monopolise the widespread distribution of misinformation (Farmer 2020; Freeman et al. 2020). With competing and increasingly highly charged strident voices, this has fuelled the rise of fake news and the era of post-truth. In this situation feelings override facts, and objective information, e.g. science or health information, is less influential in shaping public opinion than appeals to emotion and personal belief (O’Connor and Murphy 2020; Rose 2020). Complex health and other socio-scientific issues are particularly vulnerable to manipulation by social media because they are emotionally charged topics that can challenge people’s beliefs in uncomfortable ways, as exemplified in the debates about MMR and anti-vaccination campaigns (Numerato et al. 2019; Arede et al. 2019), climate change (Farmer and Cook 2013; Cook et al. 2017) and more recently COVID-19; for example, that the 5 G mobile phone network is causing or exacerbates the virus, that the virus was bioengineered in a lab in Wuhan, or that President Trump’s claims that injecting bleach or other disinfectant is a cure for COVID-19 (van der Linden, Roozenbeek, and Compton 2020).

The need for accurate information is of critical importance to limit the spread of misinformation about the virus (Rose 2020). As Roozenbeek et al. (2020a) state, scientists have a key role to play in this battle as disseminators of factual and reliable information but as a single strategy this is unlikely to be effective. Altering public perception and beliefs is hampered by the proliferation of insidious and plausible online misinformation (MacKenzie, Rose, and Bhatt 2020). According to Rose (2020, page 818) this causes ‘negative epistemic postdigital inculcation’, that is;

the repetitious exposure to false, misleading, or inaccurate epistemic resources through digital media that become tacit epistemological resources and impact on beliefs and behaviour.

Becoming familiar with misinformation through continual exposure makes it more likely that a person will consider it as the truth. This problem is exacerbated by the formation of online homophilous groups where people gravitate towards others who share the same opinions and beliefs, and through a process of mutual agreement their views are reinforced and validated (Mihailidis and Viotty 2017). Belonging to one or more of these homophilous groups is comforting and reassuring, especially during times of crisis, such as the COVID-19 pandemic. A reduction in social mixing during lockdown may have increased the proliferation of COVID-19 related misinformation as individuals sought out company in online echo chambers where misinformation about COVID-19 could have become reinforced and entrenched (Roozenbeek et al. 2020a; Thi; Nguyen 2020).

It is clear that education has a key role to play in combatting this onslaught of misinformation about COVID-19 but separating out facts and reliable evidence from the pseudoscience and overcoming susceptibility to misinformation is not an easy task (Iammarino and O’Rourke 2018; Rose 2020; Roozenbeek et al. 2020a). This is a complex process and requires students to have accurate knowledge but to also acquire positive epistemic resources, including the ability to think critically, become more discerning about sources of online information and honing decision-making skills (Arede et al. 2019; Rose 2020; Roozenbeek et al. 2020a). However, Cook et al. (2017) have shown that interventions based on inoculation theory to explain flawed arguments about misinformation about climate change or highlighting the scientific consensus for anthropogenic global warming was effective in counteracting misinformation. More recently, the online games *Bad News* and *Go Viral!*, also based on inoculation theory that aims to counteract the deluge of misinformation about COVID-19, have been shown to significantly improve players’ ability to spot and resist misinformation but also their ability to better identify real or credible news (Guess et al. 2020; Roozenbeek et al. 2020b). For teachers of science and health, this is encouraging as these activities could form part of a battery of tools to combat misinformation and more generally be employed to improve students’ criticality, argumentation and decision-making skills. Apart from combatting the problems associated with misinformation about COVID-19, the pandemic can bring opportunities for biology educators. Michael Reiss (2020) argues that the history, philosophy and sociology of science should be integrated into lessons about COVID-19, and as a socio-scientific issue there are profitable interdisciplinary connections that can facilitate scientific and health literacy.

The COVID-19 pandemic has left many of us wondering how we can be reliably informed about the virus and what we can believe to be accurate public health information so that we are able to act upon it with certainty. As noted above, the surfeit of news available each day has made it more difficult to distinguish between real and fake news. For students, this may have been heightened as a result of fewer opportunities to learn about the pandemic by asking pertinent and timely questions during lockdown, and when they are in school teaching has become more formal and didactic. Students’ understanding of the pandemic and its associated factors is therefore likely to be at best partial and possibly confused, and as a result, some may be scared (Reiss 2020). We were therefore mindful that students may be concerned about the information they were receiving about COVID-19, what aspects of the news stories they could rely upon as accurate, and furthermore what elements – accurate or not – may be worrying them. We considered that armed with reliable

information, students may be better able to understand news stories as they were reported, whilst counteracting some of the misinformation on social media platforms that they may have relied on more than usual during the pandemic. Therefore, we thought it was important to ask students what they wanted to know about COVID-19 so that these questions could be addressed in lessons when they returned to school in June 2020, after lockdown was lifted. We also decided to repeat the exercise when they returned to school in September after the long summer break, during which students again potentially had to rely on a variety of news sources, and we considered that the students may have a different set of questions because the information about COVID-19 was changing, often quite quickly.

The research questions we aimed to answer were:

- (1) What do 15 year olds want to know about the scientific and social aspects of COVID-19?
- (2) Do these questions change over time?

Methods

This small-scale exploratory study took place between June and September 2020. The participating students were 15 year olds (Year 10) attending a large co-educational state secondary school in the south east of England. At two points in time (T1 and T2) students were sent an individual voluntary online homework exercise that required them to complete a pro-forma in response to the question: 'What are the 5 most important things you'd like to know about COVID-19 (coronavirus)?' They were able to write the answers in free text form, and although there was no word limit applied, the nature of the question resulted in short sentences and at times one-word answers. Using an online homework task to implement data collection allowed the researchers to invite voluntary participation of an entire year group. Although the sample was smaller than we had anticipated, the successful student participation demonstrated how online questionnaires are an accessible format for students and the short time they needed to answer the pro-forma evidenced the low impact the research had on their everyday lives (time for completion ranged between 1 and 5 minutes for T1 and T2). An online research platform was also regarded as advantageous, particularly during the pandemic, as the presence of a researcher within the educational establishment was not required. The data was also collected individually by each participant using their own device, so the possibility of contamination of data through student interaction was reduced.

As noted above, the T1 and T2 surveys were both immediately after long periods of being out of school, so the students had to rely on sources of information about COVID-19 other than school. T1 was in June, just prior to returning to school after the first lockdown, which had been in place since March, and T2 was in September following the summer vacation.

Qualitative content analysis was adopted as the main method of analysis of the responses from T1 and T2 to obtain qualitative and quantitative findings from the data (Mayring 2015). The students' responses were compiled on a spreadsheet and analysed following Braun and Clarke's (2006) stages for thematic qualitative analysis. The responses were read and re-read independently by two of the authors who coded and categorised them and amalgamated the categories into broad themes. Two of the authors then independently assigned a sample (20%) of the students' responses according to these themes. Cohen's kappa (k) statistic for intercoder reliability was then applied to the content analysis, and this showed substantial agreement between the authors ($k = 0.79$). The themes were also subject to quantitative analysis by counting the frequency of each of the themes and then applying descriptive statistics to present the findings quantitatively.

We note here that the whole study took place before news broke of new, faster spreading variants, which later became dominant across the country. This was announced by the government on 14 December. Consequently, none of the questions raised by the students included mention of new variants.

To contextualise the students' responses, we are setting them against a background of the main COVID-related news headlines at the times they were surveyed (T1 and T2). Ofcom (2020) reports that among 12–15 year olds, talking to the family (68%) and watching TV (67%), are the commonest ways to find out about news, followed by social media (55%) and talking to friends (49%). On TV, the most important news source is the BBC (17%), although many social media sites are also used. 12–15 year olds also consider family and radio, then TV, to be the most truthful news sources, and social media and friends are considered the least truthful sources (Ofcom 2020). We have therefore drawn on the BBC news headlines as a reasonable indication of the overall COVID-related situation at T1 and T2 (cf. BBC News archives, e.g. https://archive.org/details/BBCNEWS_20200616_010000_BBC_News).

The tasks students were asked to complete were deemed to be part of normal school activities and therefore covered by school policy with respect to ethical issues. Furthermore, all responses were anonymous and taking part was a voluntary activity.

Findings

There were 142 students in the cohort, and the response rates at T1 and T2 were 49 (35%) and 30 (21%), respectively. Whilst this is not considered to be representative of the student population, the responses explore what this age group wanted to know about COVID-19, and as such provide an indicative illustration of their questions. The students' questions were wide-ranging but quite short, and this may have been as a result of the nature of the task. Nevertheless, seven main themes were derived from the data at T1 and T2, and these are shown below.

- (1) Aetiology – causes and origins
- (2) Incidence and distribution
- (3) Risk factors and virulence
- (4) Control measures – prevention and cure
- (5) Safety rules
- (6) Symptoms and immune response
- (7) Personal aspects, normality, the future

Quantitative analysis involved ranking the questions in each theme at T1 and T2 according to the total number of times questions relating to each theme were raised (see Table 1).

To provide some context to the findings, the general background situation relating to COVID-19 and key events for T1 and T2 are summarised in Table 2.

Students' questions at T1

At T1, the most frequently asked questions were about incidence and distribution of the virus, followed equally by personal aspects, aetiology of the disease and risk factors. Questions about incidence and distribution tended to be of a socio-scientific nature related to the epidemiology of

Table 1. Ranking of data.

Theme	T1	T2	Ranking T1	Ranking T2
Causes and origins (aetiology)	29 (16%)	12 (11%)	3.5	6
Incidence and distribution	43 (23%)	27 (25%)	1	1
Risk factors	29 (16%)	12 (11%)	3.5	6
Control measures	20 (11%)	15 (14%)	5	3.5
Safety rules	17 (9%)	17 (15%)	6.5	2
Symptoms and immune response	17 (9%)	12 (11%)	6.5	6
Personal aspects	30 (16%)	15 (14%)	2	3.5
Totals	185	110		

Table 2. The general situation relating to COVID-19 and key events for T1 and T2.

Survey dates	General situation and key events
T1 11– 19 June 2020	<p>England has been in lockdown since 23 March, but an easing was announced for 13 June allowing people to visit another household as part of a ‘support bubble’. Schools began to reopen on 1 June. The weekly COVID-19 related deaths in the UK is 1,203 and falling steadily.</p> <p>June 11 Government says its ‘test and trace’ system is working well, but it fails to track down a third of people who tested positive.</p> <p>June 13 94% of doctors who have died with COVID-19 are from non-white backgrounds.</p> <p>June 14 Government considers reviewing the 2 m social distancing rule to the disapproval of many medical experts.</p> <p>June 15 Non-essential shops reopen for first time since March.</p> <p>June 17 Announcement that the cheap steroid Dexamethasone can make a ‘massive difference’ to COVID patients in hospitals and will be available in the NHS for COVID-19 treatment.</p> <p>June 18 The Government’s test and trace system is only managing to trace 75% of people who tested positive.</p> <p>June 19 Report that people from ethnic minority backgrounds are being hardest hit by COVID. COVID alert level was reduced after a continuing decrease in the number of cases.</p>
T2 10–16 Sept, 2020	<p>COVID-19 levels beginning to increase rapidly across the country. Government’s ‘Hands, Face, Space’ slogan was launched on 31 July. The Oxford-AstraZeneca vaccine trial is halted as a volunteer became ill. Schools are open but only 88% of pupils returned in the first week. If people test positive they and people in their bubble have to self-isolate for 2 weeks. Some schools are telling whole year groups and classes to self-isolate. The weekly COVID-19 related deaths in the UK is 110 but beginning to rise again steadily.</p> <p>Sept 10 Due to a sudden rapid increase in people testing positive, the Government announces the ‘rule of six’ where people must not meet socially in groups of more than six people (although schools are exempt).</p> <p>Sept 11 People, including schoolchildren, are being turned away from COVID testing centres due to testing capacity problems. Report showed that 65% of people testing positive were asymptomatic. The R value of COVID-19 transmission in the UK rises above 1 for the first time since early March.</p> <p>Sept 12 The Oxford-AstraZeneca trial resumes.</p> <p>Sept 15 New rule in some places that people can meet in parks and open spaces, but not in each other’s homes or gardens.</p>

the disease and the impact on society of the pandemic. Their questions illustrated students’ desire for further information about the social relevance of COVID-19 at a personal and societal level, the controversial nature of the origins of the pandemic, its epidemiology and how the news was reporting on these issues as well as moral and ethical dimensions about how countries, particularly the UK, were dealing with the pandemic. For example, questions about future outbreaks were concerned with the impact of the pandemic on society and included:

How soon, if ever will the second wave occur?

Will it return on a yearly basis?

Will it ever disappear completely?

Are we going to have a second wave?

Will it come back again once this is all over?

The terminology used by students frequently reflected the vocabulary used in the media with many referring to, ‘a wave’ or, ‘a second wave’. Some students asked about the implications of easing the lockdown on the prevalence of the virus, indicating their concerns and awareness of the potential for further outbreaks. These questions also implied that students were seeking answers about what decisions should be made to combat the virus at a personal and societal level:

Whether releasing lock down will cause another wave?

Are we safe if we get back to our normal lives?

The rate of deaths since lockdown was eased?

Do you think the rate of COVID will be higher once we are in July?

Other questions highlighted students' desire for accurate scientific information and focused more broadly on the R number, rates of infection and deaths, with students asking about local as well as wider geographical incidences of infection.

Accurate death rate in [school's location]?

I'd like to know if the COVID-19 rate is actually going down in the UK

Why does the USA have so many cases?

Daily death rate?

Questions focusing on the students' own personal issues tended to be 'non-scientific' but had a cultural and societal element with questions about returning to 'normal' being frequently posed, for example:

'This might be a bit hard to answer but do we know approximately when things might get back to normal?'

The students phrased their questions in terms of the uncertainty about their future, particularly about the effect of the pandemic on their education, and travel. They were usually written in the first or second person denoting the personal nature of these questions, but they also raised broader social and moral issues about government policy, for example, the impact of school closures on education and how crucial examinations will be managed:

Will our GCSE's [national exams] be made easier next year, I was quite scared of doing them before all of this happened. (I know you cannot tell us this at the moment as the government are useless and you receive the same information as the public do at the same time).

I am finding it really difficult to motivate myself at home and it just seems like there is so much work, I have been good at completing it but this week I have fallen behind. Maybe we could have 1 day a week where optional work is set so we can catch up?

Will this effect travelling abroad in the future?

Will this effect if I want to study abroad in university?

The themes of the origins and causes of the disease (aetiology) and risk factors and virulence tended to elicit scientific and socio-scientific questions that highlighted particularly controversial aspects of the pandemic. Students were interested to know about the stories that were in the news concerning where the virus came from and were seeking confirmation of the story or possibly reassurance about potential misinformation, for example:

Is it really from bats?

Where it came from within Wuhan?

Was it man made?

What is the source of the virus? I have heard bats are carriers but I have seen conflicting information

Why did the Chinese make a global pandemic in a lab?

Did the Chinese start the virus to get money?

Questions about risk factors and virulence were predominantly about the speed of transmission of the virus within the population and how contagious it is. These questions illustrate students' anxiety about the risks posed by COVID-19 and their need for reliable information:

How come it is so deadly?

Why did the disease spread so quickly?

Can kids die?

How easily does it spread amongst teenagers?

Students were also interested to have accurate information about routes of transmission and the risks posed in particular situations:

In What Ways Can It Be Spread?

Is it possible to catch it from food?

If someone near you with corona sneezed or coughed can the wind make it spread to other people near?

If one person had it in the school is there a chance that it will rapidly spread?

How long does the virus stay on books for?

Is 2 metres enough?

Less prevalent were questions about control measures, safety rules and symptoms. Although questions were raised that illustrate students' interest in the medical and scientific aspects of the combating the virus, for example; students asked about potential cures and vaccines, e.g. *How long will it take to find a cure/vaccine? How can the virus be treated?* Questions about safety rules were of a socio-scientific nature and were related to the efficacy of the measures in place to prevent the transition of COVID-19 and interestingly replicated the later, 'Hands Face Space' mantra. Some students, if not entirely sceptical, seemed to be questioning the level of impact of these measures, for example: *Does hand gel actually help? Why [do] we have to wash our hands? Can we wear masks to school? Social distance?* Whilst questions about symptoms were more scientific in their orientation in which students were seeking scientific factual information:

Can people have it without any symptoms?

How [does] it affects the human body?

What happens to the body when you get it?

This ‘snapshot’ of students’ questions at T1 clearly indicates that the majority of questions were of a scientific or socio-scientific nature and elicited a wide range of issues. The students were not only interested in finding out more about the scientific facts related to the COVID-19 pandemic but also how to understand and make informed decisions about the social, cultural and moral issues the pandemic raises. Addressing the cross-curricular aspects raised by the students’ questions has implications for dealing with the complexity of socio-scientific issues in school science. Questions about the incidence and distribution of COVID-19 were prevalent; but there were also a substantial number of non-scientific ‘personal aspects’ questions, particularly with respect to anxieties about the future and returning to ‘normal’. Interestingly, students’ questions rarely aligned directly with the news headlines at that time shown in Table 2. The students did not ask any specific questions about support bubbles, test and trace system, shops reopening, Dexamethasone or the disproportionate number of non-white deaths – although the latter may be unsurprising as the majority of students are White British with very small numbers from ethnic minority backgrounds. However, students wanted to know about data related issues such as the R rate and death rates, the resurgence of the virus in a ‘second wave’, the possibility of a cure or vaccine and safety measures. These questions suggest that students were aware of media reports and daily news bulletins but that they wanted to know more.

Comparison of students’ questions between T1 and T2

Scientific and socio-scientific questions were again prevalent in most of the themes at T2, and the same themes were derived from analysis of responses at T2 as T1, indicating that students were asking the same or remarkably similar questions at both time points. This may be due to not having their questions answered satisfactorily in June or that information and advice was changing rapidly and at times seemed contradictory. These questions illustrate students’ concerns about the controversies surrounding policy decisions in managing the pandemic and their implications for societal and personal decision-making:

Why are we made to wear masks when at first the government said it was useless? How can their findings change so quickly?

*If we are only allowed in groups of six, then why are we going to school in groups bigger than six?
Why have we gone back to school on higher daily cases than when we left?*

At both time points, the most frequently asked questions were about the incidence and distribution of the virus, which has a moral and ethical dimension, as they may be attributed to the continuing concerns students have about the threat of virus and also the predominance of statistics about R rates and death rates in the news.

Questions about safety rules and control measures became more frequent at T2, and this aligns with the change in news and information regarding the debates about social distancing, the rule of six and the use of face masks over the summer, and it may have reflected students’ anxiety and confusion about what to believe with regard to the efficacy of control measures, e.g. ‘Do the droplets seep through masks?’ and as noted above.

Personal aspects also remained a frequent theme, although questions about travel had disappeared, and the education-related questions focused on the social and political issues with respect to the overall impact on schools and the resulting implications for students and the education system in general:

What is the longevity of the schools system? Will it become safe for staff and students in the future if cases rise again and will the level of education be high enough to ensure we are taught at the same level as past students?

I know that certain things have been taken out of our curriculums but do schools expect us students to take similar GCSE exams as past years when we have both missed half a year of effective learning . . . which almost certainly would have had an effect on their grades making them different to what they were expected by their teachers?

Questions about origins and causes as well as risk factors were both relatively high at T1 but became less frequently asked at T2, perhaps because by this time the disease had lost its ‘newness’ and some risk factor issues, such as ‘Is it possible to catch it from food?’, had been generally addressed.

Overall, the questions suggested that whereas the situation at T1 was novel and worrying with a lack of reliable information, at T2 the students were becoming more accustomed to a new ‘normal’ as increasingly more scientifically reliable information became available. However, some questions were of an existential nature and still indicated fear, e.g. ‘will I die?’

In terms of the social situation, news headlines at T2 differed from T1 in that the COVID-19 levels and deaths were again beginning to increase rapidly, and it was becoming clear that many people who tested positive were actually asymptomatic, and the government introduced stricter social grouping rules (called the ‘rule of six’).

Interestingly, there were a very small number of questions at T1 (4) and none at T2 that reflected some scepticism about the reality of the danger posed by the virus, e.g. ‘Are we really as at risk as they say?’ Whilst a questioning attitude (scepticism) that interrogates scientific claims is a necessary aspect of socio-scientific reasoning, the majority of students were not doubting the seriousness of the virus and by T2 they were all aware of the impact of the pandemic on themselves and society. The questions students raised at T1 and T2 indicate that they recognised the complexity and multiple perspectives of the COVID-19 pandemic, and had the desire to find out more. These are also essential attributes for socio-scientific reasoning in order to make informed decisions about socio-scientific issues.

Discussion and conclusion

The COVID-19 pandemic is a current, controversial socio-scientific issue (SSI), which directly affects us all in some way. Herman, Newton, and Zeidler (2021) highlight how little research has been conducted on ‘how students respond when immersed in and taught through SSI in real-world contexts where they interact with people who are actually confronted with the SSI’ (p.586). This study begins to fill this gap by investigating the questions uppermost in students’ minds while experiencing a full-blown SSI first hand. The themes we identified reflect the COVID-related issues that were continually present in the news and affecting us all over this period, and suggest that students were accessing a variety of reliable sources of news (Ofcom 2020). Although the social situation and the headlines in the news were continually changing between T1 and T2, the students’ pressing questions about the disease and its consequences did not mirror the specific headlines. However, it is clear they wanted to find out about COVID-19, but unlike the students’ statement used in the title of this paper they were less certain about what to believe. Rather than, *I already know about it, I’ve been watching the daily news and updates*, most students might have replied, *I don’t know about it even though I have been watching the daily news and updates*. Despite this surfeit of news, students asked questions that were similar over time indicating that some answers had not been available or that sources of information were confused, and at times contradictory (Roozenbeek et al. 2020a; van der Linden, Roozenbeek, and Compton 2020). This is exemplified by some comments such as, *Why are schools open if we are in lockdown? And, How [can we] prevent the disease from spreading within the school environment because I feel that measures to protect ourselves could be a little clearer . . .*

On a more positive note, students wanted reliable and accurate information and their questions appeared to be based on reliable sources of news. Additionally, there were very few questions, or comments that reflected fake news throughout the time of the study. It seems that the students had not been influenced by the misinformation that according to some has predominated on social media during the COVID-19 pandemic (UNESCO 2020; Rose 2020). It is encouraging that this finding seems to contradict the literature that suggests that young people are particularly vulnerable to believing this sort of information (Roozenbeek et al. 2020a; Rose 2020). Amazeen & Bucy (2019) note that those who are media literate are more resistant to misinformation. The students in this study did not seem susceptible to conspiracy theories that have been circulating on social media and elsewhere whilst they also appear to have paid more attention to *bona fide* news rather than fake news, suggesting they have a functional level of media literacy.

As de Walque (2011) states, pandemics have a negative impact on the general wellbeing, mental and physical health, and educational outcomes, and the students did express their anxieties about the future across the whole study period. Similar to findings by Brooks et al. (2020) and Rose (2020) this suggests that the anxiety caused by the pandemic is long lasting and perhaps also reflects the uncertain and changing information provided about the virus. And this can make students confused and even scared (Reiss 2020). The immediate anxiety felt by students towards their personal health and wellbeing, for example, the fear of dying, reduced slightly over time, and this could be a product of fatigue or familiarity with the news, as well as the lockdown restrictions becoming the 'new normal'. But students also indicated concerns about returning to school and questioned whether it was safe to do so (Rao 2006). The longer term concerns about students' personal and collective future were still prevalent at T2, e.g. the impact of further waves on their education and at a societal level. This will require further research as the impact of long-term school closure on educational outcomes, and the wellbeing of young people, has not yet been fully explored (Viner et al. 2020).

Apart from those of a personal nature, the questions students asked were about science or socio-scientific issues; for example the risk to their own and others' health, the aetiology and epidemiology of the virus, symptoms and the scientific basis for the efficacy of control measures. This is not very surprising as health and the pandemic caused by COVID-19 are socio-scientific issues. Socio-scientific issues have their basis in science, have relevance for society, often making a large impact on society globally, and consider controversial real-world problems that may include an ethical dimension (Ratcliffe and Grace 2003; Sadler, Barab, and Scott 2007).

Connecting scientific knowledge with broader social issues is seen as educationally advantageous in enabling students to gain science [and health] 'functional literacy' to improve their criticality, argumentation and decision-making skills (Zeidler et al. 2005). The questions from students also indicated a high level of interest in the topic. This is encouraging for science teachers as they can capitalise on using this real-world health-related issue to provide a student-friendly approach to learn about the underpinning science concepts of COVID-19 and other zoonotic diseases (Byrne and Grace 2018). In relation to the SARS outbreak, Lee (2008) noted that teachers could also encourage students to view this socio-scientific issue from a wider perspective by discussing such topics as the impact of information flow, healthcare management, human rights, and political and economic considerations to broaden their understanding; in doing so this puts the science in context. These issues are all pertinent and worthwhile aspects to explore with respect to the COVID-19 pandemic as an authentic and current socio-scientific issue that can help to develop socio-scientific reasoning, strengthening student decision-making skills to facilitate scientific literacy. However, Lee (2008) also warns that there are challenges for science teachers in managing SSI's in the classroom. Of relevance to this study are the social and moral questions the students asked. As noted in the findings, these go beyond the remit of many science curricula and teachers' expertise. Many of the questions were of a cross-curricula nature. The challenge for science teachers and science education is to grasp the opportunities afforded by the issues raised in these questions to make connections with other parts of the curriculum, including citizenship education, history, social/political studies and religious education. Students will then have a wider range of resources

and reference points to employ to inform their decision-making within these socio-scientific contexts. We do not underestimate the challenges that such an approach brings, but we are heartened by the arguments put forward by Reiss (2020) who has argued that, as a socio-scientific issue, COVID-19 offers valuable interdisciplinary connections that can facilitate students' scientific and health literacy.

We acknowledge that there are limitations to the study in terms of the sample size and the brief responses to the questions. Further research is necessary to ascertain broader and more comprehensive student views about COVID-19. Nevertheless, within the scope of this small-scale exploratory study, the findings offered a range of nuanced responses from the students that will be of interest to teachers planning lessons about COVID-19 in particular and pandemics more generally. The findings will also be of interest to researchers working on socio-scientific issues, and students' decision-making in an era of misinformation, as well as science and health literacy.

To conclude, students wanted to have accurate and reliable information and yet despite accessing *bona fide* news sources they were still uncertain about what to believe. Science lessons offer an ideal opportunity to discuss socio-scientific issues such as the COVID-19 pandemic, facilitating students' decision making skills and enhancing their scientific literacy.

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